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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO FORMING FORGED GEAR

(71) We, TRW INC., a Corporation organized and existing under the laws of the State of Ohio, United States of America, of 23555 Euclid Avenue, Cleveland, Ohio 44117, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the forming of a forged gear.

The invention provides a method of forming a forged gear, the method comprising the steps of positioning a shaft within a die cavity having gear teeth shaping cavities at the periphery thereof, positioning a hollow forging billet about the shaft, the billet having its outer periphery in spaced relation to the cavities, the billet being at a temperature at which it is relatively plastic, and applying downward pressure on the billet to cause compaction along the axial dimension of the billet and radial flow of the metal of the billet into the cavities, the pressure being sufficient to form gear teeth in the billet and to join the shaped billet to the shaft with a metallurgical bond.

The method is not confined to shafts of circular configuration, as the shafts may have any type of cross-sectional configuration. One of the advantages of the method of the invention is that the shaft and the forged gear can be composed of different materials, provided the shaft has a softening point in excess of the forging temperature employed for the shaped gear. The invention thus provides a low cost method for joining a precision forged gear on a shaft, whether solid or hollow.

The invention will be better understood from the following illustrative description and accompanying drawings, in which:

Figure 1 is a fragmentary view, partly in elevation and partly in cross-section of an apparatus suitable for the practice of the present invention;

Figure 2 is a cross-sectional view taken substantially along the line II—II of Figure 1;

Figure 3 is a fragmentary view, partly in elevation and partly in cross-section of a modified form of apparatus which can be used in the practice of the present invention;

Figure 4 is a cross-sectional view taken substantially along the line IV—IV of Figure 3;

Figure 5 is a view similar to Figure 1 but illustrating the position of the components during the forging and bonding operation; and

Figure 6 is a view similar to Figure 3 but illustrating the position of the components during the forging and bonding step.

In Figure 1, reference numeral 10 indicates generally the forging die apparatus which can be employed in the practice of the present invention. The die apparatus 10 includes a bottom bolster 11 having a recess therein which accommodates a back-up block 12 therein. The back-up block 12 rests on a shim 13 through which a kicker pad 14 and its associated shaft 16 are arranged to reciprocate to eject the finished piece from the die.

A forging die ring 17 is tightly received within a forging die ring clamp 18, the latter being secured to the back-up block 11 by means of bolts 19 or the like.

The apparatus shown in Figures 1, 2 and 5 is arranged to simultaneously forge a spur gear and join the same to a hollow shaft. To that end, the internal periphery of the forging die ring 17 is provided with gear teeth shaping cavities 21 as best illustrated in Figure 2 of the drawings. As best seen in Figure 1, the internal diameter of the cavity in the forging die ring 17 is sufficiently large to loosely receive a billet 22 to be forged, the billet in this instance being a hollow cylinder. Simultaneous with the forging operation, the forged shape is joined to a shaft 23 consisting of a hollow tube extending through the back-up block 12 and engaging the kicker pad 14 as shown in Figure 1.

The tube 23 is centered in the die assembly by means of a cylindrical mandrel 24 which forms part of the punch assembly. The mandrel 24 is received in floating relation within a punch element 26, the latter being secured

between a top bolster 27 and a punch clamp 28 by means of bolts 29 or the like. The mandrel 24 has a headed portion 31 which is received in sliding relation within an axial bore 32 formed in the punch 26. A coiled spring 33 is disposed between the headed portion 31 of the mandrel 24 and a plug 34 which is received in threaded engagement in the top of the punch 26. A second coil spring 36 is positioned between the lower surface of the headed portion 31 and a stripper ring 37.

In operation, the billet 22 is slipped down over the free end of the tube 23, the billet 22 being heated to a forging temperature. In the case of steel or the like, a temperature of about 1900°F. or so would be appropriate. The billet may be pre-coated with a flux capable of dissolving oxides on the billet. The press assembly is then tripped and the punch 26 descends, clearing the tube 23 and exerting a compressive force on the billet 22. Continued movement of the punch 26 causes the metal of the billet 22 to be compressed axially and to flow radially outwardly to fill the gear teeth forming recesses 21 in the forging die ring 17. At the same time, the extreme compaction of the metal billet 22 causes it to flow radially inwardly and become bonded to the outer periphery of the tube 23 with a metallurgical bond. The lower extension of the mandrel 24, being disposed in the area where the billet 22 is plasticly urged against the tube 23, supports the tube 23 against inward bulging which is particularly necessary when a thin walled tube is being employed.

After the metal of the billet 22 has been extruded radially to fill the cavity of the forging die ring 17 and to bond itself to the outer periphery of the tube 23, the punch 26 is raised. The spring loaded stripper ring 37 is provided in the event there is a tendency for the tube 23 to seize on the floating centering mandrel 24. The forged part is then raised by the kicker pad 14 and removed from the die assembly.

The provision of the floating centering mandrel 24 with the spring 33 and 36 acting on the headed portion 31 of the mandrel is particularly useful where it is required to provide close control of shaft runout. In other instances, of course, the floating type mandrel may not be necessary.

The embodiments shown in Figures 3, 4 and 6 are closely similar to those of the other figures, but differ mainly in the fact that the shaping portion of the assembly is provided on the punch rather than in a forging die ring. In the embodiment illustrated in the drawings, reference numeral 41 refers to a back-up block which is bottomed on a bottom bolster 42 with a shim 43 being interposed therebetween. A kicker pad 44 secured to a shaft 46 is provided for ejection purposes. A guide member 47 guides a punch assembly 48 over the back-up block 41. A forging billet 49 of annular configuration is loosely received on the back-up block 41 with its inner periphery spaced from the outer periphery of a tubular shaft 51 as shown in Figure 3.

The punch assembly includes a mandrel having a lower extension 52 serving to center the tube 51 and to prevent buckling thereof during forging operation. The mandrel 52 has a headed portion 53 against which a spring 54 is bottomed. The other end of the spring is bottomed against a plug 55 in threaded engagement within a suitable bore provided in the punch assembly.

As best illustrated in Figure 4, the bottom end of the punch assembly is provided with gear teeth shaping recesses 56 which, during the forging operation, operate on the billet 49 to force the metal to flow radially thereby filling up the recesses 56, and causing bonding to occur between the inner periphery of the billet 49 and the outer periphery of the tubular shaft 51. This condition is illustrated in Figure 6 of the drawings. At the completion of the forging operation, the punch is raised, and the kicker pad 44 ejects the forged gear, now bonded to the tubular shaft, from the die assembly.

As previously mentioned, the metal of the forged gear and the metal of the shaft may be different as, for example, when the forged gear is composed of steel and the shaft is composed of titanium. This type of construction permits a reduction in weight, lower cost or both. Another variation consists in providing a gear with a steel toothed ring and a titanium web.

In the event that a very high torque application is required, the shaft to which the gear is joined can be knurled, flattened or grooved prior to forging in order to provide a higher strength bond between the gear and the shaft.

From the foregoing it will be understood that the present invention provides an economical method for simultaneously forging a precision gear onto a shaft while bonding that gear to a portion of the shaft, whether hollow or solid. Through the use of the method of the present invention, one can use dissimilar metals in the shaft and in the forged gear to utilize the best properties of each.

WHAT WE CLAIM IS:—

1. A method of forming a forged gear, the method comprising the steps of positioning a shaft within a die cavity having gear teeth shaping cavities at the periphery thereof, positioning a hollow forging billet about the shaft, the billet having its outer periphery in spaced relation to the cavities, the billet being at a temperature at which it is relatively plastic, and applying downward pressure on the billet to cause compaction along the axial dimension of the billet and radial flow of the metal of the billet into the cavities, the pressure being sufficient to form gear teeth in the billet and

to join the shaped billet to the shaft with a metallurgical bond.

2. A method as claimed in claim 1 in which the shaft is hollow.

3. A method as claimed in claim 2 having the step of supporting the hollow interior of the shaft during forging to prevent buckling.

4. A method as claimed in claim 1, 2 or 3 in which the billet and the shaft are composed of different metals.

5. A method of forming a forged gear substantially as herein described with reference to Figures 1, 2 and 5 or Figures 3, 4 and 6 of the accompanying drawings.

6. A forged gear formed by the method of any preceding claim.

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1265137 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

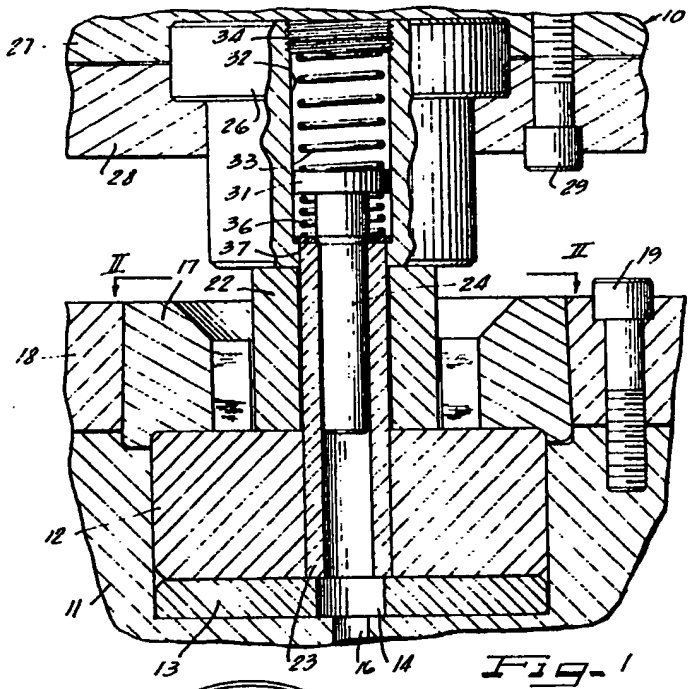


Fig. 1

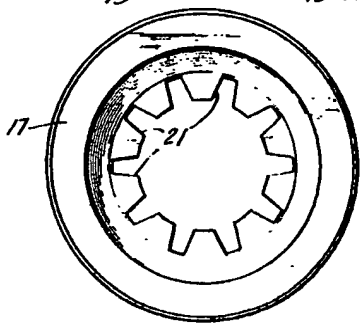
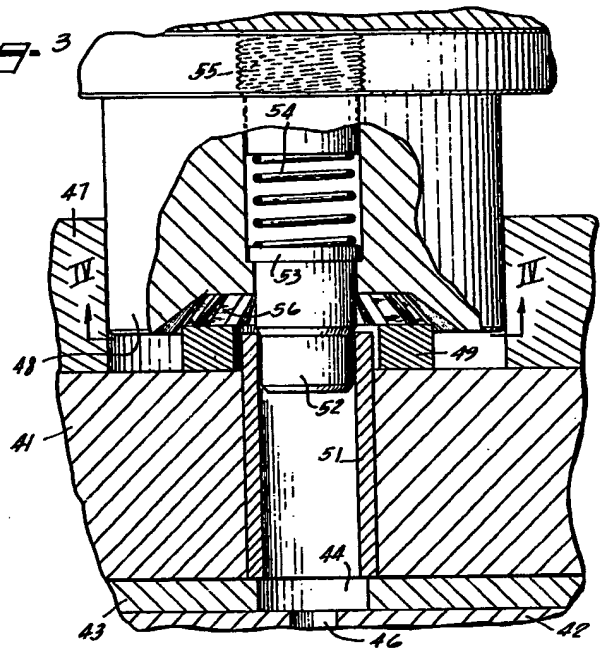


Fig. 2

Fig. 3



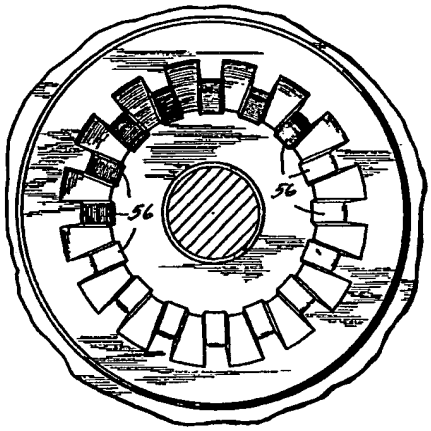


Fig. 4

1265137 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

Fig. 5

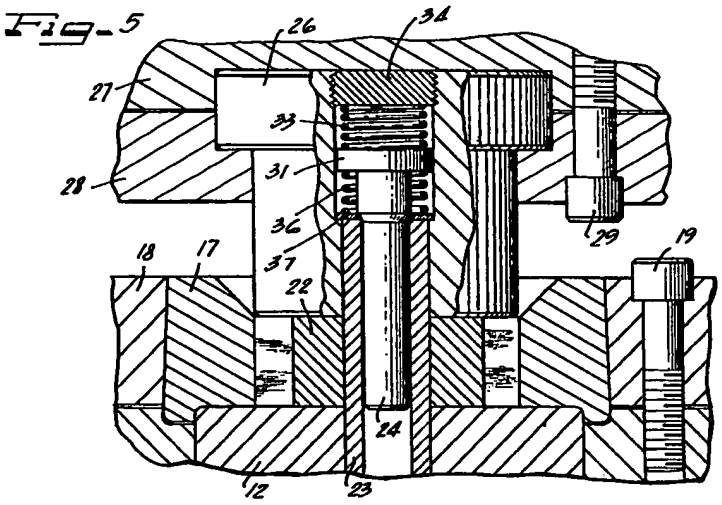


Fig. 6